Space Weather Technical Forecast

Issued on Sunday, 30 July 2023 at 01:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: S1/Moderate Radiation Storm gradually easing. R1-R2 Blackouts likely throughout. G1-G2 Minor/Moderate storms possible 01 Aug with CME arrival.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Moderate with one M-class flare observed, an M1.4 at 29/1624 UTC from AR3380. There are 11 sunspots in total on the disc, with AR3380 and AR3386 the most complex. AR3380 has developed significantly over the last 24 hours in both length and visible appearance. AR3386 appears to be stable but is notably complex. The remaining regions appear small or simple, but several regions close to the eastern limb could reveal further complexity. Activity from beyond the limb, including a farsided CME close to the east limb, suggest that further active regions will rotate into view through the next few days.

One Earth-directed CME was observed early on 29 Jul, with a partial halo visible on coronagraph imagery from the large filament eruption in the northeast disc. No other Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: Solar wind speeds were at ambient levels through much of the forecast period but steadily increased from around 29/0800 UTC to reach close to 450km/s. Density started below average, but reach close to average levels, before a decline towards the end of the period in line with the solar wind increase. This suggests a weak CIR ahead of coronal hole high speed stream. Total magnetic field strength was mainly weak, but reached moderate levels from around 29/2200 UTC due to the likely coronal hole influence. The north-south component, Bz, varied weakly throughout. Phi angle was predominantly positive (away from the Sun), but became indeterminate from 29/2200 UTC. Geomagnetic activity was Quiet to Unsettled.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux rose above S1/Minor Storm at 28/2350 UTC, in response to the far-side eruption on 28 Jul. and reached S2/Moderate Storm levels by 29/0530 UTC, but has now declined to and plateaued at S1/Minor Storm level. Proton flux peaked at 154 pfu at 29/0920 UTC, but has now fallen to 52 pfu. GOES16 high energy (greater than 2MeV) electron flux ranged between moderate and background levels. 24-hour integrated fluence was 2.68e7 integrated pfu at 30/0000UTC.

Four-Day Space Weather Forecast Summary
Solar Activity: Low to Moderate activity is forecast, with a very slight chance of Strong activity.

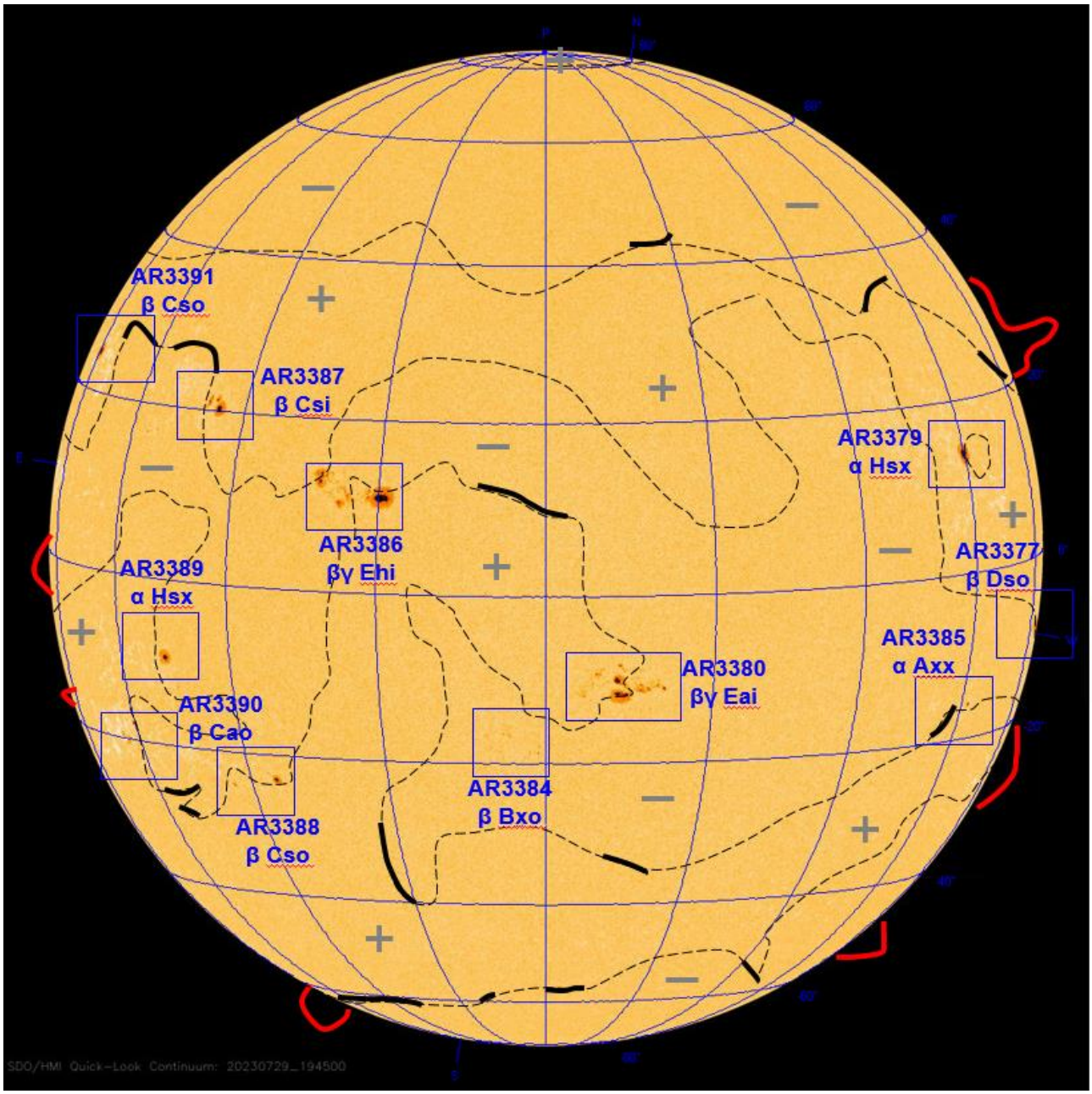
Solar Wind / Geomagnetic Activity: A partial halo CME which left the Sun early on 29 Jul is forecast to arrive at Earth on 01 Aug. No further Earth-directed CMEs are forecast. A weak coronal hole high speed stream, from an unidentified feature appears to be affecting the Earth, with effects expected to decline during 30 Jul. Quiet with isolated Unsettled geomagnetic activity expected through 30 and 31 Jul. Activity then expected to reach peaks of Active or G1/Minor Storm during 01 Aug due to the CME arrival, with residual impacts then possible into 02 Aug. there is also a slight chance of G2/Moderate Storms.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to gradually, but erratically ease through the period, but likely remaining above the S1 threshold until the arrival of the expected CME on 01 Aug. The high energy electron flux (greater than 10 MeV) is expected to continue at background to moderate levels with the associated fluence expected to remain below the Active threshold (1e8 total pfu).

Figure 1. Solar Analysis Valid 29/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

A large filament eruption from the northeast quadrant early on 29 Jul produced a partial halo and has been analysed as having an Earth-directed component. Arrival is forecast for 01/1000UTC with an error bar of 9 hours. No other Earth directed CMEs are expected within the forecast period. There is a very slight chance of the CME arriving earlier with risks of geomagnetic enhancements extended into late on 31 Jul. Depending on the timing of arrival and magnitude of impact, enhancements could be observed into 02 Aug.

Solar winds has recently shown a response, possibly due to a weak CIR (co-rotating interaction region) ahead of a coronal hole high speed stream. As the solar wind is only just starting to show a response, this will be monitored. The response appears to have resulted in a modest solar wind increase to 430km/s and a northward orientated magnetic field. As any coronal hole is not visible on SDO imagery, this feature is likely to small, with an enhancements in the solar wind expected to be short-lived.

Geomagnetic activity is forecast to be mainly Quiet with isolated Unsettled intervals on 30 and 31 Jul. The arrival of the CME, most likely on 01 Aug is likely to produce Active to G1/Minor Storm periods, with a lower chance of G2/Moderate Storms and a very slight chance of G3/Moderate Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	10	60	30
Strong	G3	No	1	1	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

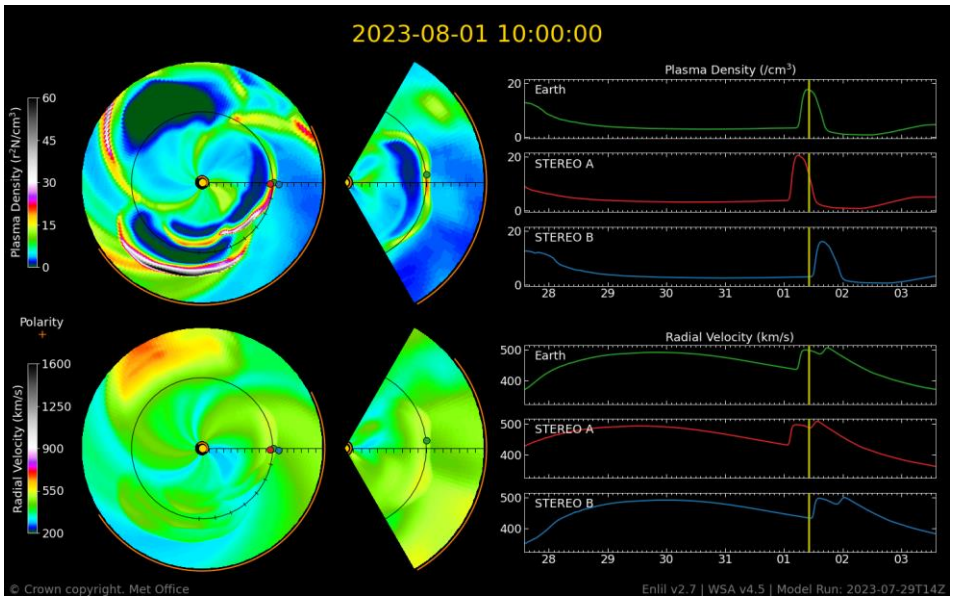
Geomagnetic Activity - Earthbound Coronal Mass Ejections

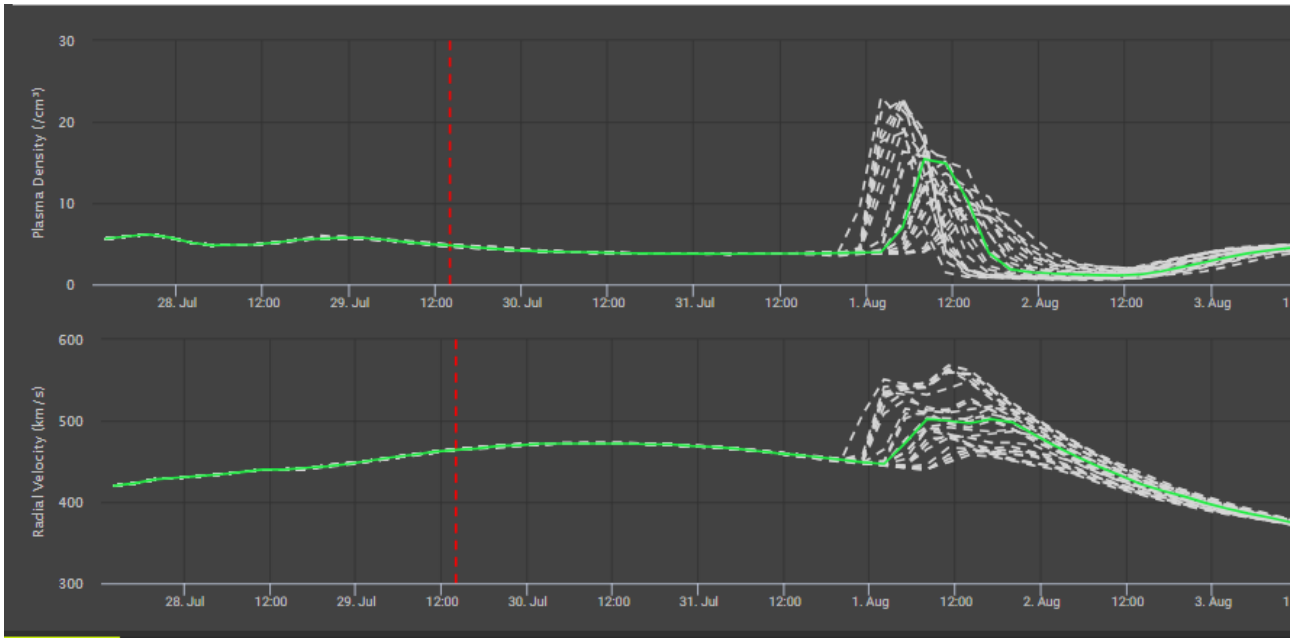
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
29/0550	Partial Halo	Filament	NE	505 km/s	01/1000 +/- 9 hours	Limited shock expected

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: MOSWOC Enlil model showing forecast arrival and MOSWOC Enlil ensemble showing range of arrival times. The relatively tightly packed results suggest a moderate confidence in arrival times.





Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

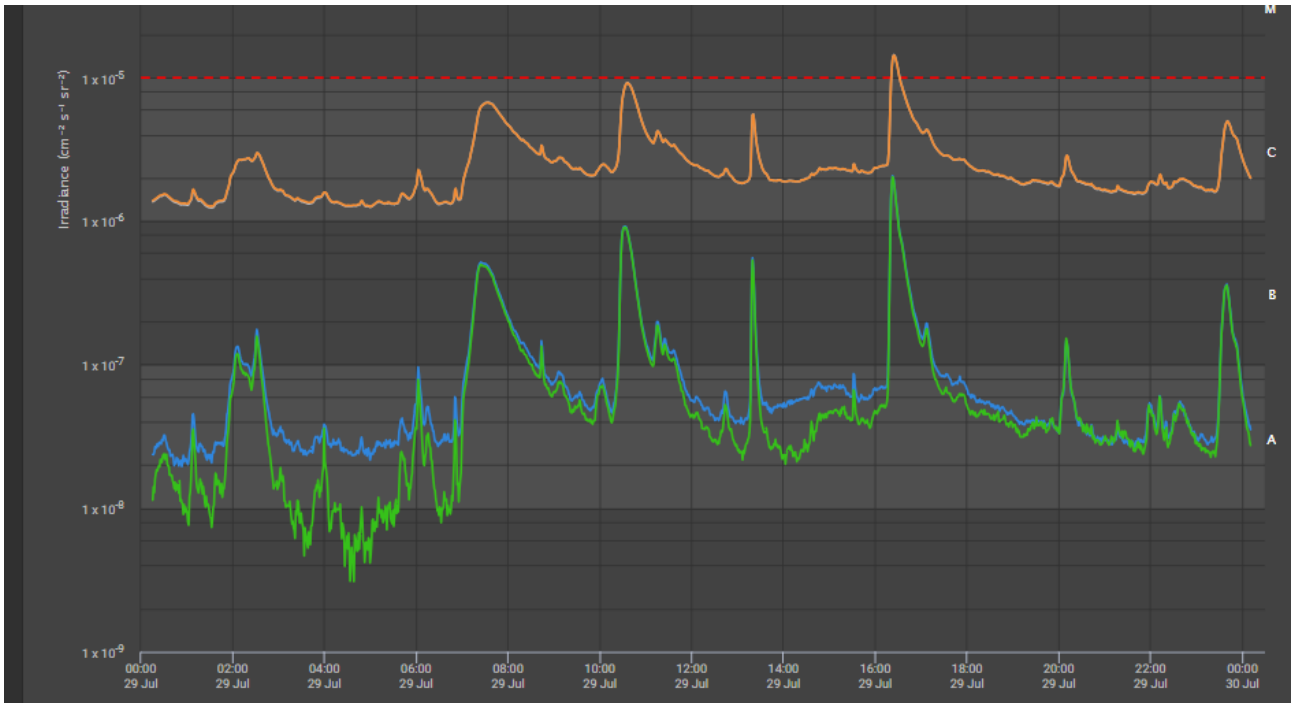
Radio Blackouts - X-Ray Flares:
There are 11 sunspot regions on the visible disc, with large and complex regions AR3380 in the south centre disc and AR3386 in the northeast. AR3380 has been the most active and developmental of the two regions, producing a M1.4 flare late on 29 Jul. The remaining regions all appear relatively simple, but a number of these are still emerging across the eastern limb and will be monitored for further complexity and activity.

Beyond the limb bright flux is visible, which suggests that further regions may appear through the period, continuing to enhance solar activity.

Low to Moderate activity is expected with a slight chance of X-class flaring.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16 X-ray flux, showing the one M-class flare from AR3380



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

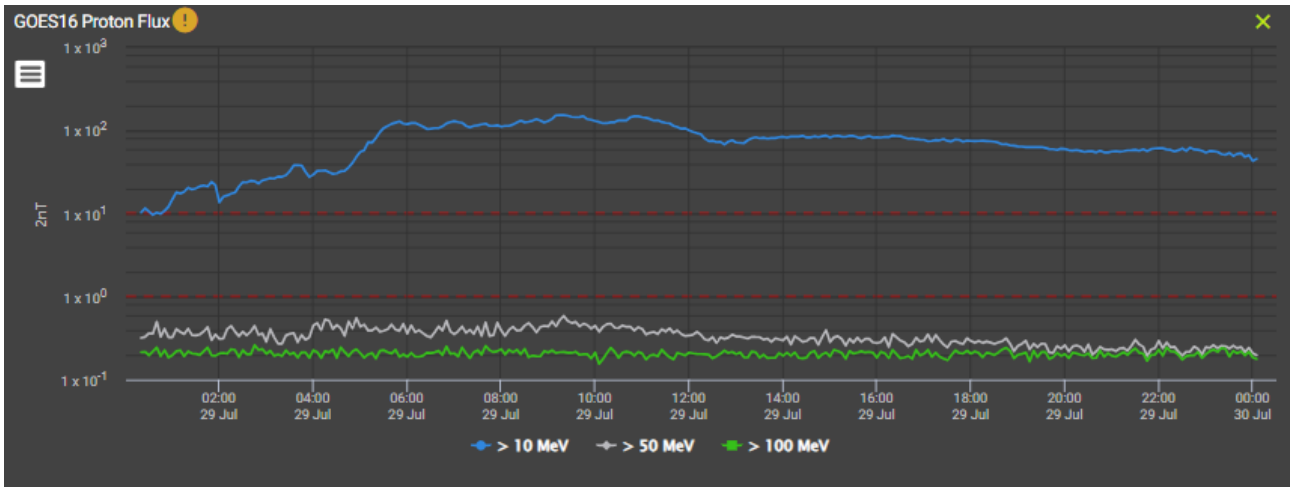
Solar Radiation Storms - (High Energy Protons):
The large far-side eruption, from the vicinity of ex-AR3376 over the northwest limb, resulted in an S2/Moderate Storm being observed by GOES-16. Peak flux has now plateaued at S1/Minor Storm and is likely to gradually and erratically decline in the absence of further enhancements. Any further large flares from this region still have the potential to produced observable proton flux at Earth, although this risk is diminishing as it continues to move further onto the far-side.

The majority of the visible spots in the western hemisphere are small and considered low risk of producing proton rich flares. AR3380 has developed into a complex region and now is now rotating across the western side of the Sun. AR3386 is further to the east and will not cross into the western hemisphere for another two days.

Overall a declining trend is expected through the period, with a brief spike in proton flux possible due to the transition of the CME on 01 Aug.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	90	70	60
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES 16 Proton Flux. This peaked at S2, but has now fallen to the S1 level.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) is expected to oscillate between background to moderate levels, with a slight risk of exceeding the high threshold through 30 and 31 Jul. This forecast is however uncertain, as the electron flux observations are subject to contamination from the ongoing proton storm. On 01 Aug and 02 Aug a CME arrival is forecast, which could suppress counts by distorting radiation belts away from observations at GEO.

Electron fluence values are on a steady trend, with a falling trend expected later in the period due to the potential CME effects.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.